Maths and the Muses: Mosaics

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'A Mathematician, like a painter or a poet, is a maker of patterns.' This comment, by one of the century's greatest mathematicians, G. H. Hardy, started me off on a train of thought on the importance of pattern in ancient art and literature. The Greeks and Romans valued and pioneered many aspects of mathematics, and their discoveries are reflected in their art. It was in the art of the Roman mosaicist that the blend of mathematical patterns with visual flair perhaps appeared most pronounced.

The craft of the Muses

The Greeks and Romans assigned the arts concerned with pattern, including intellectual pursuits like maths, music, and philosophy, to the goddesses called the Muses. Now, the word 'mosaic' derives from the Latin 'opus musivum': the art of the Muses. It is an art which is both extremely practical and which embodies the most abstract mathematical principles of geometry: in other words, it demonstrates pattern at the visual, practical, and mathematical levels. A mosaic is simply a design built up from 'dots', normally tiny tiles of fairly regular shape, called ' tesserae' (or 'tessellae'); sometimes they are arranged in shapes which tessellate (regular polygons). The tesserae are usually of regular size in each section of a mosaic (though complex mosaics have bands of different-sized tesserae).

The use of tesserae made the craft practical: mosaic floors and even wall coverings were durable and cheap (at least until Byzantine times when rare precious metals and glass were used); they could be made up by workmen from pattern books derived from combinations of patterns devised by artists. Sometimes the patterns are inspired by geometrical forms, sometimes figurative, but in essence the medium is non-figurative, deriving inspiration from pattern. A modem mosaicist suggests that the best training for the craft is to link mathematical experiment with shapes to the scrutiny of natural forms (skeletons, dissected fruit, poppy heads, and even scrapyard machinery, gears, cogs etc.). A nice example of geometric pattern built up from regular shapes is the Tour Eiffel. Interestingly, this was painted by the 'pointilliste' Seurat who used his 'dots' of brush rather as a mosaicist uses the elements of his tesserae.

Ancient mosaics can be explored then, as examples of art inspired by mathematical pattern.

Mathematics

The Greeks and Romans valued mathematics highly. Our word 'mathematics' comes from the Greek 'mathema' – 'subject concerned with learning' (not restricted to numerical or quantitative learning; the word became associated with this kind of learning because the Greeks set such store by it). Plato's Philosophy Academy had the following inscribed over the door: 'No one ungeometrical may enter'. 'Geometry' comes from 'geometria' – 'measuring the earth' – and it was geometry which the Greeks most valued. Measuring the earth was the activity which led to the discovery of the reasoning principles or patterns which so delighted the Greeks and Romans. The closer one looks at the geometrical patterns underlying even the simplest of mosaic designs, the clearer their mathematical basis emerges. The notion of a mathematical proof seems to have come from pictorial representation of numbers and shapes. If numbers are visualized as set patterns of dots, a connection can be seen between early mathematical thinking and mosaic tiling.

Designing without machinery

There were practical applications of the Greek and Roman fascination with geometry, too: town planning, surveying, measurement, and mapping for example. Gradually, simple measuring and surveying instruments were devised. What is perhaps surprising and salutary in an age of calculators and computers, however, is the discovery that mosaicists laying out their tesserae according to complex blueprints, where the rows and curves had to meet up for the pattern to work, did so without machinery or sophisticated surveying knowledge. They used age-old methods using folded lengths of cloth or string; these methods required a practical understanding of geometry rather than technology.

Grids and nets

A great many Roman mosaics seem to be based upon a square grid. We can understand the principles of their composition (and perhaps get ideas for using them in our de signs) by attempting to draw them. If this is done stage by stage, the structure of the patterns can be analysed.

The simplest kind of mosaic pavement would simply be a tessellated mass of tesserae of the same size and regular shape. This could be developed in three simple ways: (1) Variation in the size of tesserae could be used in certain areas. (2) Some tesserae could be set at an angle from the rest. (3) Colour contrast could be used (as in chess board patterns).

Far more interesting patterns can be used, however, by developing the potential of the grid and repeats within it. This diagram shows some basic grid 'nets' and how geometric shapes emerge from them:

A grid could be laid out according to the string method shown above. The net for a floor at Bignor Villa (Sussex) could have been laid using the simple string method:

Nowadays for convenience in drawing out the designs on paper, squared paper is useful (though the more complicated designs need isometric paper).

Study of the nets used in mosaics from all over the Roman Empire has led to classification of patterns according to basic geometric shapes.

Triangles

This pattern is found in a pavement from Pompeii. It needs a grid of 14 x 14 squares, and the triangles are neatly obtained from the squares:

Hexagons

The grid above shows how a hexagon is formed. The following diagram shows in stages (top to bottom) the elements of a design used on a complex pavement at the Roman Palace at Fishbourne (the best site for Roman mosaics in Britain):

Cubes

Lozenges can give the illusion of three-dimensional cubes when three are put together to form a hexagon. There is a '3D' floor at Pompeii:

Colour would obviously contribute to the effect (at Pompeii coloured marble was used). When colour emphasizes the 3D effect, the pattern is known as 'Tumbling Blocks'. Here is a design for a patchwork quilt developed by a modern needle-workerfrom a floor at St Mark's, Venice:

Knots

As a centrepiece, or to fill gaps, knots could be used, such as this one, known as a guilloche knot, Solomon's knot, endless knot, or lovers' knot:

Over 1,000 Roman mosaics have been discovered in Britain alone. More are being uncovered annually. Some, sadly, have been either destroyed or covered up permanently because of the cost of maintaining them. The most famous example is the great Woodchester mosaic, which used to be uncovered every ten years but is now buried permanently. The Romans regarded mosaics as so much a part of their artistic and domestic culture that Julius Caesar is reputed to have taken prefabricated sets of tesserae for mosaics with him on his Gallic campaigns for laying down in camp! To see Roman mosaics go to the nearest Roman villa or museum. If you study and draw them you will learn instinctively about pattern and geometry. You might also be inspired to use the designs creatively, as designers like Fassett have, or even to create your own mosaics. Go to Tottenham Court Road Underground Station, and admire the colourful wall mosaics by the Italian artist Eduardo Paolozzi. The opus musivum is not a dead craft, any more than Latin is really a dead language. Just as Latin and its literature continues to enrich European languages and literatures, so the ancient patterns and techniques of the Roman mosaicist are still being used by artists today.

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